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Coastal Barrier Breaching, Part 1: Overview of Breaching Processes

by Nicholas C. Kraus, Ty V. Wamsley

PURPOSE: The Coastal and Hydraulics Engineering Technical Note (CHETN) herein provides information about the causes of breaching of coastal barrier islands and spits, with emphasis on breaching near inlet navigation projects and measures to prevent breaching. Subsequent technical notes in this series will present case studies and models under development in the Coastal Inlets Research Program (CIRP) for predicting the inception and evolution of breaches.

BACKGROUND: In a coastal context, a breach is a new opening in a narrow landmass such as a barrier spit or barrier island that allows water to flow between the water bodies on each side. Every year around the coast of the United States, breaches occur on barrier islands, barrier spits, and closed river mouths. Breaches occur naturally or they can be purposefully dug or dredged, and a breach may have positive or negative consequences.

Unintended breaching of barrier islands and barrier spits is often a serious concern to society and the U.S. Army Corps of Engineers (USACE). A breach can cause:

a. Loss of human life.

b. Accelerated destabilization of jetties.

c. Increased costs of jetty repair and channel maintenance dredging.

d. Reduction or loss of protective natural beach and dunes.

e. Loss of navigability in adjacent inlets sharing the same water body as the breach.

f. Loss of property by flooding, wave attack, and erosion;

g. Loss of access to property.

h. Immediate loss of habitat.

i. Exposure of the bay or estuarine environment to ocean waves and stronger currents, causing gradual loss of habitat and property through redistribution of sediment.

j. Unwanted increases in salinity and water level.

Breaching is, therefore, a phenomenon to be accounted for in the navigation, coastal storm damage reduction, and environmental restoration and sustainability missions of the Corps.

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A breach may close naturally, or it can increase in size and become a new inlet. A new inlet created by breaching may compete favorably for stability with existing inlets in the same bay system, promoting their closure. A trend toward closure of an existing inlet will render the navigation channel unreliable as well as alter the environment because of changes in water level, circulation, and salinity. A breach next to a jetty has potential for undermining the structure. It is possible that a breach adjacent to a jetty will compete for flow that would otherwise scour the authorized channel, causing the navigation channel to shoal. Construction of a breach closure is costly. In addition, nearshore or beach material that had been protecting the structure and the shore may move into the navigation channel because of the breach, and its removal by dredging adds unanticipated cost to inlet entrance maintenance.

BREACH PROCESSES: Breaching potential is achieved if the water level on one side of a narrow barrier spit or island exceeds some critical elevation that is not necessarily above the barrier beach and dunes. Breaching can happen in two ways: by overtopping and by seepage and liquefaction.

Overtopping. A breach can occur if running surface water scours a trough between the sea and the body of water protected by the barrier. A certain duration of inundation is required, as well as a strong flow, and breaching is promoted by wave action and the presence of a pre-existing localized area of low elevation in the barrier island that can confine and intensify the flow and scour. The inundation can proceed either from the seaward side or from the bay (estuary, lagoon, or river) side. Breaching by overtopping can occur from the seaward side during times of sustained high water level and large waves during storms or from the bay side if the bay water level is raised under extreme precipitation in the bay and its watershed. Strong wind during a storm can set up the water level at a barrier and promote sustained flow either from the sea or from the bay. Wave setup and runup contribute to the inundation, and the presence of waves in the incipient breach will increase sediment mobilization and transport.

Seepage and Liquefaction. If the barrier spit is narrow, seepage through the porous sediment caused by a difference in water elevation on the sides of the barrier can liquefy the sediment-water mixture, allowing large volumes of material to be transported quickly as slurry. This type of breaching usually occurs from the bay side because of the long duration of higher water level that is possible in an enclosed or nearly enclosed water body, and it is not necessary for the water level to have reached the top of the barrier spit or island.

Breaching potential is minimized if the barrier is high and wide. Barrier elevation and volume above mean sea level are key factors for resisting inundation and erosive wave attack during times of higher water level. On the Atlantic Ocean and Gulf of Mexico coasts, incipient breaching typically occurs from the seaward side during storms through the combination of storm surge (an increase in average water level above predicted astronomical tide) and large waves accompanying tropical storms, hurricanes, and northeasters. High water levels in the bay or lagoon may open the breach quickly in ebbing, once the breach is initiated from the sea side.

At times of intense precipitation by coastal storms or through heavy rainfall in the watershed, breaches originate from the bay side because of high bay or river water level, causing either seepage and failure of the barrier or scour by water flowing over the barrier toward the sea. On the Pacific

coast, breaching typically occurs from the seaward side during large storms following a series of preceding storms that created a depleted beach and dune by establishment of a runnel near and parallel to a jetty. On the coast of Texas, breaching from the lagoon or bay side can occur after tropical storms or hurricanes that bring large amounts of rainfall. On the California coast, enclosed lagoons and mouths of small rivers tend to open after rainy season (Kraus, Militello, and Todoroff 2002), for which seepage and liquefaction are the dominant process.

The destructive forces of breaching and constructive forces of breach filling are illustrated by reference to Figure 1, which shows two breaches at Westhampton, Long Island, NY, facing the Atlantic Ocean. This barrier section was breached from the ocean side during the subtropical storm of 11-13 December 1992 (Terchunian and Merkert 1995; Bocamazo and Grosskopf 1999). The initially larger breach opened at a location that was later called Pikes Inlet, creating wing spits and a flood shoal in the bay. Pikes Inlet attained more than 304.8-m (1,000-ft) width. At the same time, a shallow 30.48-m- (100-ft-) wide breach that could be walked through opened to the east at a location subsequently called Little Pikes Inlet. This small breach was initially prevented from growing by underlying peat deposits, which resisted erosion. The U.S. Army Engineer District, New York, closed Pikes Inlet in January 1993 by placement of 60,000 cu yd of material dredged from the nearby Intracoastal Waterway. Pikes Inlet had tended toward closure because of the littoral sand supply located to the east. In contrast, winter storms and lack of sediment supply caused Little Pikes Inlet to grow to more than 914.4 m (3,000 ft) in width, creating small wing spits and a large flood shoal. Tide range and salinity in the back bay increased while the breaches were open. The two breaches cut the access road to houses and the county park located on their west side.

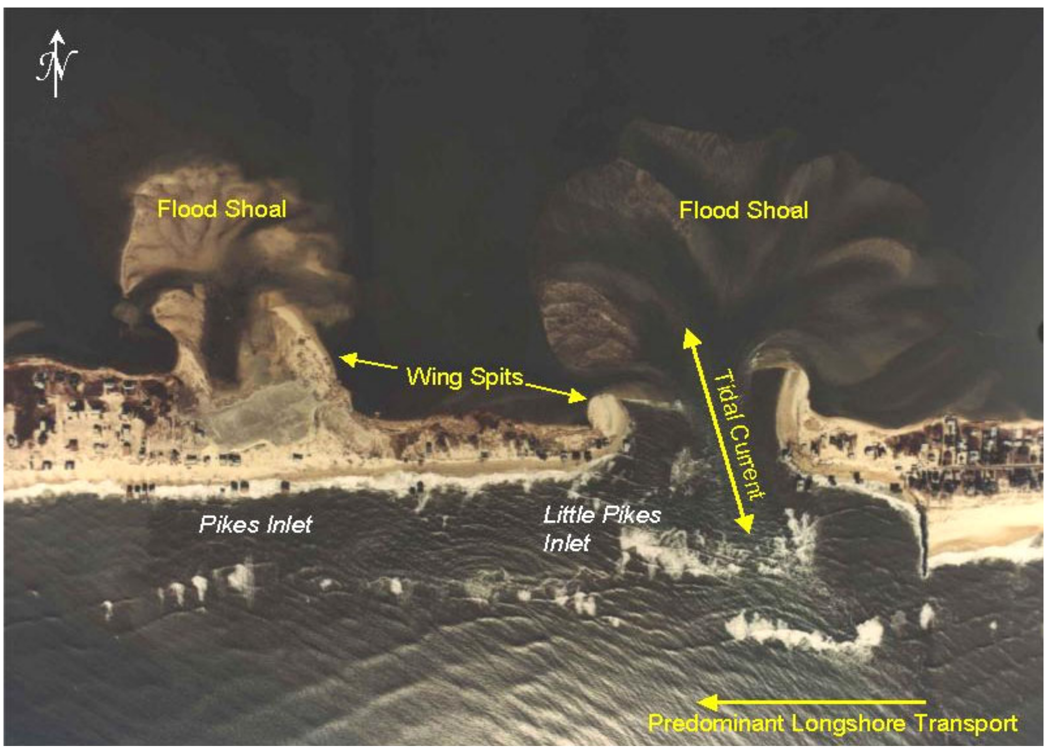


Figure 1. Breaching of barrier island at Westhampton, Long Island, NY, December 1992. Photograph taken 7 March 1993 and furnished courtesy of First Coastal Corporation, Westhampton

Little Pikes Inlet became a semipermanent inlet because the longshore supply of sand was reduced by the Westhampton groin field located to the east and directly updrift (Nersesian, Kraus, and Carson 1992), so that scour by the tidal current could overcome the weak amount of infilling from longshore sand transport. The New York District initiated breach closure in May 1993 that was completed in November 1993 by hydraulic placement of approximately 1.6 million cu yd from two offshore borrow sites (Bocamazo and Grosskopf 1999). Subsequently, the New York District and New York State developed a breach-contingency plan for a 91.7-km (57-mile) reach of Long Island barrier islands. The breach contingency plan involves maintenance of stockpiles of sand (obtained from channel dredging) for reinforcing barrier dunes and reducing breach potential during storms. The plan has protocols for assuring rapid communication lines to coordinate actions between New York State and the New York District, which can be found at (*http://www.nan.usace.army.mil/fimp/*).

This CHETN contains a short discussion of purposeful breaching of coastal barriers, then focuses on natural breaching and concerns to coastal inlet jetties and navigation channels.

PURPOSEFUL BREACHING: Some coastal ponds, lagoons, and blocked river mouths are breached mechanically for environmental reasons with the expectation that they will close after a short time by the natural process of longshore sand transport. Common reasons for cutting a breach are to reduce water level in an enclosed body that might cause flooding of neighboring property; to decrease or to increase salinity in the lagoon or bay; to promote water exchange for improving water quality; and to facilitate migration of marine organisms.

Another reason for breaching a barrier is to relocate an inlet or river mouth that has migrated alongshore. The U.S. Army Engineer District, Galveston, is considering relocating the mouth of the San Bernard River, TX (Figure 2), which empties into the Gulf of Mexico. The spit has grown westward under longshore sand transport, and the migrating river mouth has become inefficient, raising concern about flow patterns and navigation in the Gulf Intracoastal Waterway that intersects the river about a mile above (north of) its mouth. Breaching of the spit to return the river mouth to its original location will promote efficient flow to the Gulf of Mexico (Kraus and Lin 2002). Numerical and physical models of spit growth at inlets are discussed by Kraus and Seabergh (2002), and FitzGerald, Kraus, and Hands (2001) describe conceptual morphologic models of spit growth at inlets and rivers.

A breach is induced by digging a narrow channel across the barrier separating two water bodies with surfaces at different levels. If the water levels on each side of a sandy barrier are substantially different, a breach will quickly deepen and widen, the water slicing through the sand to produce steep side slopes. Growth and stability of the breach depend on maintenance of a sufficiently strong flow, as driven by the head difference and any flow from a river, tide, and wind. If the barrier separating a small body of water from the sea is breached, it will close naturally because there will not be a sufficient along-channel current to sweep away the sediment entering the opening by longshore transport. Seabergh and Kraus (1997) describe a simple method for determining tidal inlet stability based on bay area and tide range. The ebb shoal generated during a breach is an ephemeral feature, unlike the flood shoals and flood wing spits that become permanent and, sometimes, vegetated because they are sheltered from sea waves.

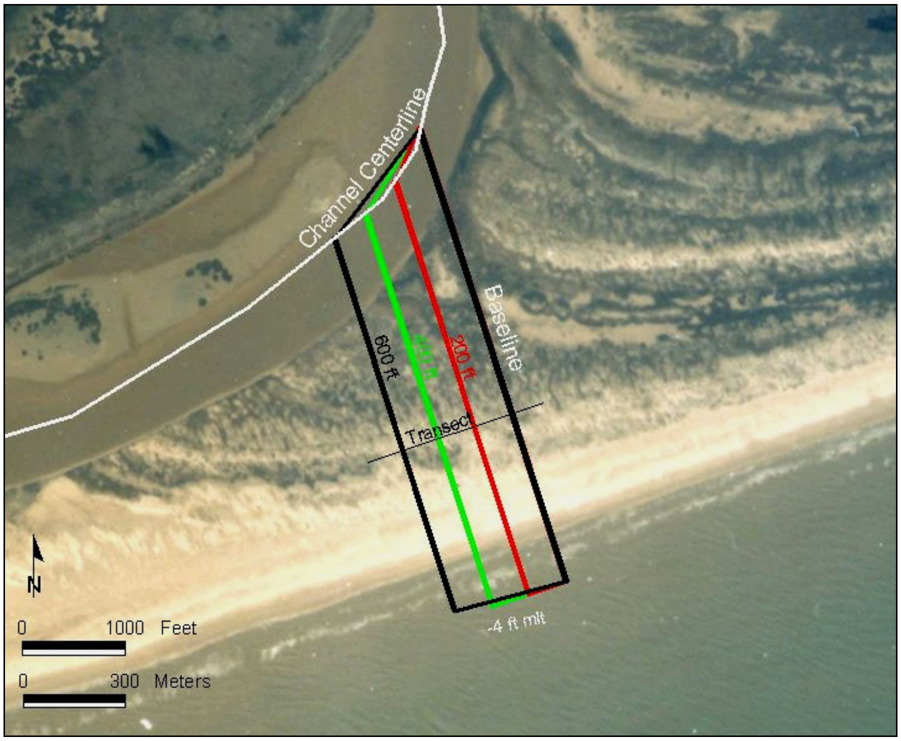


Figure 2. Alternatives for location and width of proposed relocated river channel mouth (breaching of coastal spit), San Bernard River, TX

Typically, it is desirable to breach seaward, so that filling of the bay or river mouth by sediment and seawater are minimized. To assure proper timing for the opening, a pilot channel is dredged from the pond (river, lagoon, etc.) toward the sea and from the sea toward the pond, with a plug of sand left at a convenient location on the beach berm, where it can be readily excavated. When the conditions are appropriate, such as low tide to allow seaward flow and small waves to prevent quick closure of the breach by longshore transport, the plug is excavated.

Photographs in Figure 3 were taken several hours after a breach was cut by hydraulic excavator at Mecox Pond, facing the Atlantic Ocean on the south shore of Long Island, NY. Without almost-annual artificial breaching, water level rises in the pond, and basements of bordering residences flood. The breach is left unattended to close under littoral processes, as documented by Smith and Zarillo (1988). Artificial breaching is conducted at several California river entrances such as the Carmel River, Russian River (Rice 1974), and Salinas River for such purposes as improvement of water quality, mitigation of flooding, and opening of migration paths for anadromous fish.

Mechanical cutting of breaches typically requires local, state, and Federal permits. Discharges of dredged material or fill into wetlands or other waters of the United States are regulated by USACE under Section 404 of the Clean Water Act. The Corps has permit authority under provisions of Section 404 of the Clean Water Act (33 U.S.C. 1344) and under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403), the latter concerning navigable water.

a. Looking east at breach cut through beach berm, Atlantic Ocean to left

b. Looking north toward Mecox Pond

Figure 3. Mecox Pond, breached on morning of 14 February 1998
(photographs taken in afternoon of February 14)

BREACHING ADJACENT TO JETTIES: Breaching near or adjacent to a navigable coastal inlet holds potential for compromising the functioning of the navigation project and increasing its operation and maintenance cost. A breach increases the effective cross-sectional area of the combined inlet-breach system. Because the inlet cross-sectional area and tidal prism[1] of the back

[1] Tidal prism is the volume of water that flows into or out of an inlet with the movement (rise and fall) of the tide, excluding freshwater flow. It is computed as the product of the tide range and the area of the basin at mid-tide level, or as the difference in volume at mean high water and at mean low water, typically at spring tide. The inlet cross-sectional area is that below mid tide or mean sea level.

bay have a fixed relation, increasing the inlet cross-sectional area by opening the breach will tend to decrease depth in the navigation channel. In addition, the configuration of the bay and/or flood shoal might favor the breach as the main channel in directing the tidal flow.

Preventative measures are less costly than closing of a breach and possible repair of the jetty. Navigation channel reliability may be reduced because of a breach, and property, facilities, and fragile environments such as wetlands and marshes may be compromised through exposure to waves and tidal currents.

Breaching potential is increased if the barrier beach narrows near or adjacent to a jetty. The beach can narrow or lose volume because of erosion from the sea side or from the bay side, or both. Processes contributing to erosion and breach potential are:

a. Blockage or reduction of sediment from reaching the site of the potential breach.

b. Leakage of sand through the jetty.

c. Storm inundation and wave attack.

d. Navigation channel modifications that alter the depth, location, and focus of interior wave energy.

e. Establishment of a hydraulic runnel adjacent to a jetty that creates a shortcut to low elevation backshore or back structure locations.

f. Loss of protective beach width next to vulnerable sections of jetty structures.

g. Sand transport by waves and currents origination on the bay side.

h. Natural or artificial local low spots in a dune that can be created by a variety of processes, such as by water running along the jetty and walking in fixed footpaths.

These processes are discussed next through examples at Federal coastal inlets.

Breach at Moriches Inlet, NY, January 1980. Moriches Inlet (Figure 4) is one of six federally maintained inlets on the south shore of Long Island, NY, and connects Moriches Bay to the Atlantic Ocean. Inlets to Moriches Bay have been semipermanent and migratory (Sorensen and Schmeltz 1982)[1]. In 1952-1953, rubble-mound jetties 213.4 m (700 ft) apart were constructed "in the dry" at an updrift location, and mechanical cutting of the channel was augmented by a minor storm in September 1953 to open the inlet. The net longshore drift on this coast is predominantly from east to west (right to left in Figure 4). Although the east jetty is on the updrift side of the inlet, the barrier beach narrowed because the strong ebb current directed at and along the easternmost section eroded the shore on the back side of the barrier.

[1] Historic material in this section follows that given by Sorensen and Schmeltz (1982).

a. 21 September 1980, 9 months after January 1980 breach

b. 6 October 1999, showing the revetment along eastern bay side

Figure 4. Moriches Inlet, NY. Atlantic Ocean at bottom of figures

During 16-18 January 1980, a severe extratropical storm cut the barrier at its narrowest section, and the breach expanded (Figure 4a) from an estimated 91.4-m- (300-ft-) width and 0.61-m- (2-ft-) depth on 16 January to 883.9-m- (2,900-ft-) width and average depth of 3.0 m(10 ft) by October 1980. Moriches Inlet primarily serves shallow-draft recreational vessels, and the New York District monitored the breach without immediate action. Local interests expressed concern about increased exposure to storm-induced flooding in the bay areas and changes in bay salinity on the shellfish industry. The New York District proceeded to close the breach prior to the next storm season. Sorensen and Schmeltz (1982) describe the engineering actions taken. Approximately 1.2 million cu yd of material was required for the breach closure, half obtained from dredging in the back bay and half trucked from a nearby quarry. After closure of the breach, the State of New York and Suffolk County constructed a 487.7-m- (1,600-ft-) long riprap revetment on the bay side of the beach adjacent to the east jetty (Figure 4b). The adjacent beach is part of a county park and popular for bathing and fishing.

In summary, the breach at Moriches Inlet resulted from narrowing of the barrier island, mainly through erosion on the bay side. Seabergh (2002) describes the processes and possible remedial measures for bayside erosion at inlet entrances. Because the barrier near the east jetty was narrow and low, a severe storm overwashed the weakened barrier, triggering the breach.

Breach at Grays Harbor, WA, December 1993. Grays Harbor is a large bay facing the Pacific Ocean (Figure 5). Two jetties constructed 2.4 km (1.5 miles) apart protect a deep-draft channel and stabilize the entrance. Grays Harbor has one of the largest tidal prisms in the United States. The tidal range exceeds 2 m, and the average annual wave height is greater than 2 m, with deepwater storm waves reaching heights of 8-10 m annually. Large wave heights and long wave periods, typically in the 12-20-sec range, contribute to large setup and runup during storms.

a. May 1993, 7 months before breaching

b. February 1994, 1 month after breaching

Figure 5. South jetty, Grays Harbor, WA

At Grays Harbor, the predominant direction of regional longshore transport is from south to north. The beach on the bay side of the south jetty began to erode when the jetty elevation was raised in the mid-1930s. After the south jetty was sand-tightened in the 1970s, the back bay shoreline eroded further, creating what is now called Half Moon Bay (Figure 5a). The south beach gradually narrowed, and a storm on 12 December 1993 breached the barrier spit next to the jetty (Figure 5b). A considerable amount of sand was transported into the Half Moon Bay area by a strongly flood-dominant current flowing through the breach, as compared to the entrance between the jetties, which was ebb dominant. Local interests in the city of Westport, located to the east of the entrance and just behind the breach, grew concerned about loss of land, loss of water wells and increased exposure to waves and currents. There were also concerns that further erosion would threaten the stability of the south jetty and that the eroded material may shoal the entrance channel. The Seattle District closed the breach in the fall of 1994 by placing 600,000 cu yd of sand dredged from the channel.

The barrier spit adjacent to the south jetty has continued to narrow, in particular, by enlargement of Half Moon Bay. The Seattle District constructed an innovative termination rubble mound (Seabergh 2002) at the end of the jetty to align the diffraction and refracted waves more shore normal, reducing longshore transport. A portion of the Half Moon Bay shoreline was also covered with cobble to reduce erosion, and dredged material has been placed in the nearshore of Half Moon Bay by government hopper dredge. A series of storms occurring in the winter of 2001-2002, combined with heavy precipitation that eroded material that had been placed in the breach, raised concern about the possibility of another breach. A technical committee with representatives from the Seattle District, U.S. Army Engineer Research and Development Center's (ERDC's) Coastal and Hydraulics Laboratory (CHL), local consultants, and local officials was formed to inspect the site and make recommendations. It was concluded that the jetty termination mound, existing berm, and shore-protection measures had performed as intended, and that the berm should be raised to the elevation of the natural beach along the coast. This was done, together with planting of dune grass to retain the placed sand (Arden, in preparation).

In summary, breaching at Grays Harbor during a storm in December 1993 was caused by a narrowed and lowered barrier spit. The beach had eroded both from the bay side and the ocean side. Placement of an adequate volume of sand in the breach and cobble on the bay side shoreline to reduce erosion proved effective under multiple storms. The lessons learned was that heavy precipitation could create gullies and weaken the berm fill. Therefore, planting of vegetation on the berm was considered a means for holding sand and collecting additional wind-blown sand to maintain or increase beach and dune volume.

IDENTIFICATION OF POTENTIAL BREACHES: This section discusses two inlets where breach potential has been identified near jetties, together with actions being planned or taken.

Mansfield Pass, TX. Mansfield Pass is an inlet located along the southern coast of Texas. Breaching potential exists at both the north and south jetties. As seen in Figure 6, the net direction of transport is strongly to the north. Formerly a harbor of refuge, Mansfield Pass presently provides access for shallow-draft recreational vessels and small commercial fishing boats. Maintenance dredging has decreased, and material dredged from the channel is placed on the beach of the Padre Island National Seashore adjacent to the north jetty. Insufficient volume of dredged material has

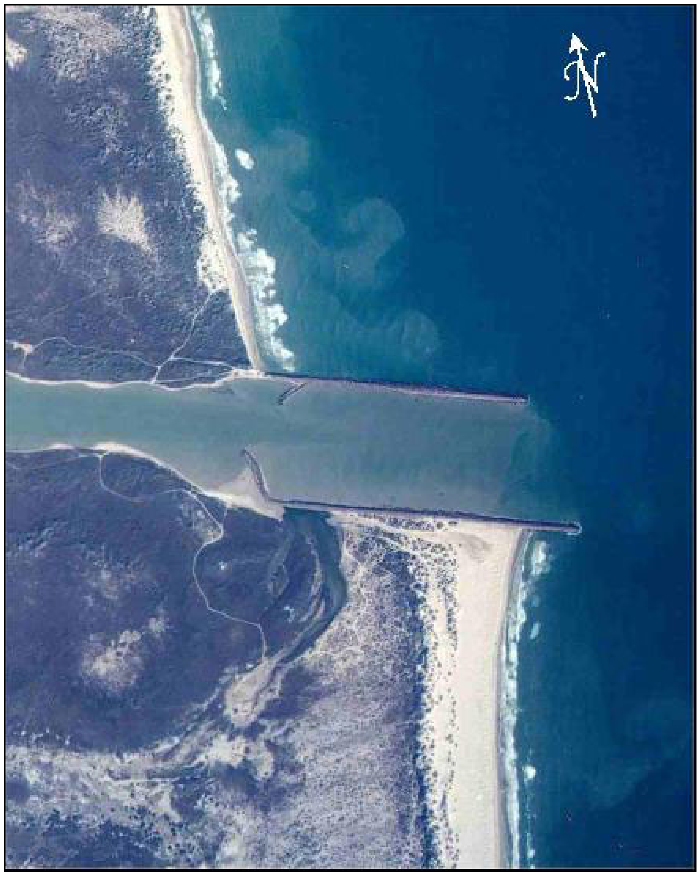


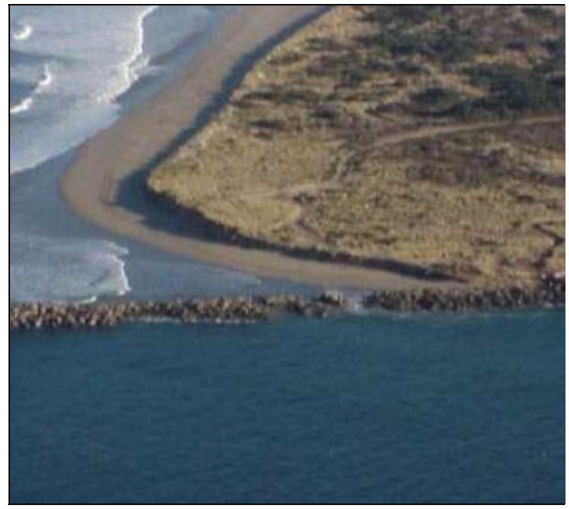
Figure 6. Mansfield Pass, TX, December 2001

required the Galveston District to consider fail-safe alternatives to prevent a breach along the north beach, adjacent to the north jetty. The alternatives include (a) a geotube or a stone revetment buried in the dune to be unobtrusive unless uncovered, (b) landward extension of the jetty, (c) placement of beach-quality material available from nearby disposal sites landward of the north jetty, and (d) combinations of (a) to (c).

The Galveston District has also noted a runnel (small channel) located along the beach next to the south jetty, apparent as a narrow strip of white sand cutting through the vegetation line in Figure 6. The runnel is probably created by surge and waves piling up water at the jetty during storms, as well as by runoff from the beach during heavy rain. This problem is remedied by dune rehabilitation and re-routing and dispersion of water pathways.

Coos Bay, OR. The north jetty at Coos Bay (Figure 7a) was constructed during 1892-1894, including a substantial effort at stabilizing the beach and sand dunes of the north spit. The 1998-1999 storm season resulted in significant shoreline recession adjacent to the north jetty. Approximately 103.6 m (340 ft) (35 percent) of the beach width was lost. In addition, a runnel or hydraulic flow path was established adjacent to the north jetty, the focusing effects of which are evident in the accelerated shoreline erosion of the vegetation line shown in Figure 7b. The combination of beach width loss and runnel creation made the back section of the jetty vulnerable to

a. View of north jetty and barrier spit, looking north



b. Close view of gaps in north jetty near the land tie-in

c. Panorama of jetty under repair

Figure 7. North jetty, Coos Bay, OR (December 2002)

overtopping; this section of jetty had a crest elevation that was 2.7 m (9 ft) lower than the seaward section. The more than 100-year-old jetty was subsequently severely damaged during a severe Pacific Ocean storm in November 2002 that removed stone near its connection to the beach (Figure 7b). The opening was approximately 30.5 m (100 ft) wide (Figure 7b), and the repair section is 152.4 m (500 ft) long. Repairs were accomplished from December 2002 (Figure 7c) to January 2003 as an emergency action. The lower crest elevation near to the shore prevents sand accumulation or impoundment at the jetty, narrowing the barrier, and increases the potential for a breach to open next to the jetty. In addition, wave energy from the channel side has increased with wider and deeper navigation channels, allowing significant wave attack from the channel side. Although this particular breach occurred in the jetty itself, there is also concern about breaching through the coastal dune into the inner embayment seen in Figure7a.

Subsequent to the jetty breach, approximately 50,000 cu yd of sediment was transported through the jetty breach and into the navigation channel. After the jetty breach was repaired, 50,000 cu yd of sand was replaced on the beach side of the breach area. This was considered essential not only to shore up the repaired jetty section but also to build back the beach which is a protective feature preventing a shoreline breach into the inner bay.

CONCLUSIONS: Numerous barrier islands and barrier spits are breached every year around the coast of the United States. Breaching can occur from the sea or bay side of a barrier by overtopping or by seepage and liquefaction. A breach may have positive or negative consequences and is a phenomenon that must be accounted for in the navigation, coastal storm damage reduction, and environmental restoration and sustainability missions of the Corps.

Barrier beaches or blocked river mouths are sometimes purposefully breached to reduce flooding potential or for environmental or navigation reasons. Unintended breaching, however, is often a serious concern to society and the Corps. Barrier beaches adjacent to jetties are particularly susceptible to unintended breaching. Breaching adjacent to a navigable coastal inlet may compromise the functioning of the navigation project and increase channel maintenance cost. Identifying potential breaches and implementing preventative measures is less costly than closing a breach and possible repair of the jetty. In addition, significant sediment volumes can be transported through a breach, potentially resulting in required dredging, destabilization of the jetty foundation, and increased erosion in vulnerable shore areas. Breach-prevention knowledge can be developed through case studies such as described here. Also, models that can predict the inception and evolution of breaches are needed for effective coastal and navigation project management, and future technical notes in this series will introduce such models as developed in the CIRP.

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REFERENCES

Arden, H. T. (in preparation). "South jetty breach fill at Grays Harbor, Washington: Doing the right thing with dredged material," *Shore & Beach* 71(1).

Bocamazo, L. M., and Grosskopf, W. G. (1999). "Beach response to groins, Westhampton, New York," *Proceedings Coastal Sediments '99.* ASCE, 2073-2089.

FitzGerald, D. M., Kraus, N. C., and Hands, E. B (2001). "Natural mechanisms of sediment bypassing at tidal inlets," Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IV-30, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Kraus, N. C., and Lin, L. (2002). "Coastal processes study of the San Bernard River Mouth, Texas: Stability and maintenance of the mouth," Technical Report ERDC/CHL-02-10, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS

Kraus, N. C., Militello, A., and Todoroff, G. (2002). "Barrier breaching processes and barrier spit breach, Stone Lagoon, California," *Shore & Beach* 70(4), 21-28.

Kraus, N. C., and Seabergh, W. C. (2002). "Inlet spits and maintenance of navigation channels," Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN IV-44, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg. MS. *http://chl.wes.army.mil/library/publications/chetn/pdf/chetn-iv44.pdf.*

Nersesian, G. K., Kraus, N. C., and Carson, F. C. (1992). "Functioning of groins at Westhampton Beach, Long Island, New York, *Proceedings 23rd Coastal Engineering Conference.* ASCE, 3357-3370.

Rice, M. P. (1974). "Closure conditions mouth of the Russian River," *Shore and Beach* 42(1), 15-20.

Seabergh, W. C. (2002). "Inner bank erosion processes and solutions at coastal inlets," ERDC/CHL CHETN IV-52, U.S. Army Engineer Research and Development Center, Vicksburg, MS. *http://chl.wes.army.mil/library/publications/chetn*

Seabergh, W. C., and Kraus, N. C. (1997). "PC program for coastal inlet stability analysis using Escoffier method," CETN IV-11, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS. *http://chl.wes.army.mil/library/publications/chetn*

Smith, G. L., and Zarillo, G. A. (1988). "Short-term interactions between hydraulics and morphodynamics of a small tidal inlet, Long Island, New York," *Journal of Coastal Research* 4, 301-314.

Sorensen, R. M., and Schmeltz, E. J. (1982). "Closure of the breach at Moriches Inlet," *Shore & Beach* 50(4), 22-40.

Terchunian, A.V., and Merkert, C.L. (1995). "Little Pikes Inlet, Westhampton, New York," *Journal of Coastal Research* 11(3), 697-703.